CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XLIX. — HISTORICAL NOTES RELATING TO MUSICAL PITCH IN THE UNITED STATES.

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Except in a very general way there is not much to be said regarding the early history of musical pitch in this country. The different manufacturers and musical organizations necessarily followed the usage abroad, and the same gradual rise in pitch that occurred there occurred here also.

The great harm arising from the excessive height to which the pitch had risen at the time was recognized by those interested in the procurement of the Great Organ for the Boston Music Hall, and when it was erected in 1863, it was tuned to the French pitch, $A_3 = 435$ double vibrations per second, corresponding to a tempered C_3 of 258.65 vibrations, which had been established in France four years before. It was hoped and expected that the result of this would be the gradual acceptance of the "normal diapason" as a standard throughout the United States. A second German organ, by the same maker, Walcker of Ludwigsburg, built a few years later for the First Church of Boston, was tuned to the French pitch, at which pitch it has remained up to the present time. Also in 1868, the French pitch was introduced as a standard into the public schools of Boston, by vote of the School Committee, although it never obtained a firm foothold there. Meanwhile the musical instruments in use by the various orchestras were still at the high pitch, and opera troupes and other foreign musical organizations employed the same standard. Serious difficulty was experienced from this cause, especially when the Great Organ was used in connection with an orchestra. After a time, in fact, at two separate periods, the Harvard Symphony Orchestra was furnished with instruments in accord with the organ, but apart from the concerts of this society, at theatres and else-

where, the performers were still obliged to use instruments at the high concert pitch, which naturally caused much annoyance. Moreover, the large organs built in this country during the years shortly following 1863, did not copy the example of the Music Hall Organ, and outside of Boston the French pitch was nowhere adopted. After much discussion, and not without strong opposition, it finally resulted that a decision was made to retune the Music Hall Organ, and raise the pitch to that ordinarily in use; the feeling of those who urged the change and finally prevailed being that while the lower pitch was desirable, and might be the pitch of the future in this country, they were concerned rather with the present, and might better wait the result of the efforts to introduce it abroad, which did not at first make rapid progress. The Great Organ was retuned in 1871 and remained thereafter unchanged at the high pitch $C_3 = 271$ vibrations, and tempered $A_3 = 455.8$ vibrations, until it was taken down in 1884.

No further serious attempt to lower the pitch in this country was made for a considerable time. A number of years later, however, when the French pitch had come to be quite generally adopted abroad, the subject again attracted attention here.

In 1882, Professor Eben Tourjée, then Director of the New England Conservatory of Music, determined to introduce the French pitch into that institution. For some reason, not wholly clear at the present time, the standard chosen was a C_3, a true sixth below the French A_3 and giving 261 double vibrations per second, and a fork of this pitch was constructed and adopted as a standard. The organ of the Conservatory was tuned to this pitch, and the fork continued to be used as the standard of the Conservatory until the close of 1897, when it was replaced by a new fork of 258.65 vibrations, a tempered sixth below the French A_3. The older fork had the disadvantage that an instrument tuned in equal temperament from it would differ somewhat in pitch from one tuned in the same temperament from an A_3 at French pitch, 435 vibrations.

Soon after this date several important orchestral organizations adopted a lower pitch than the one then ordinarily in use in the United States. In 1882 the orchestra of Theodore Thomas employed a sort of compromise pitch, slightly higher than the French pitch, viz.: $A_3 = 437.4$ vibrations. During the seasons 1881–2, 1882–3, the first and second of its existence, the Boston Symphony Orchestra employed a high pitch, $A_3 = 448.5$ vibrations, but in the fall of 1883 it adopted the French pitch as a standard, a procedure which speedily became general among American orchestras.

During the years preceding the installation of the Great Music Hall Organ, the pitch of organs and pianos shared in the general upward tendency, though instruments of the former class were not infrequently tuned at a somewhat lower pitch than that used by the orchestra. Cabinet organs intended for export were also in certain cases tuned to the French pitch. But the organ pitch commonly used was substantially identical with the high orchestral pitch, and that habitually used by piano manufacturers was often even higher.

The general lowering of the orchestral pitch in 1883 and the following years, of course necessitated a corresponding lowering of the pitch of pianos and organs used in concert with the orchestra, though it was a number of years before any general action was taken by the manufacturers.

In 1889 the National Music Teachers' Association at its Philadelphia meeting adopted the French pitch, and the National League of Musicians at Milwaukee, in March, 1891, also urgently recommended the adoption of this standard. For several years prior to this date the question of bringing the standard pitch used for pianos and organs into unison with the low pitch which had come to be the generally accepted pitch for orchestral use, had been agitated by a number of persons engaged in the manufacture of pianos and organs, and especially by the late Gov. Levi K. Fuller, of the Estey Organ Co., of Brattleboro, and Mr. William T. Miller of Boston. Finally at a meeting of the Piano Manufacturers' Association, held in New York, March 31, 1891, it was unanimously decided that it was desirable that a uniform pitch should be adopted in the United States, and a Committee was appointed, of which Mr. Wm. Steinway was chairman, and Gov. Levi K. Fuller, Secretary, to consider what standard should be adopted. This committee collected much evidence relating to the subject, and in response to a request therefor, received expressions of opinion from a large number of manufacturers and others interested in the determination of a standard, together with sample tuning-forks giving the pitch then in use by those sending them. The Committee reported in favor of the adoption of the A of 435 double vibrations per second as a standard of pitch, and their recommendation was adopted by the Association. It was also decided to call the newly adopted standard the "International Pitch."

The International pitch is of course identical with the French pitch, each having an A_3 of 435 double vibrations. Some confusion has arisen at times from the fact that the official standard A_3 made in 1859, and intended to represent the "diapason normal," is in fact somewhat sharper

than it purports to be, making, according to Koenig, 435.45 double vibrations per second instead of 435, when at the temperature of 15° C., and making exactly 435 vibrations only at the temperature 24.26° C. But the legal French pitch was defined by the rate 870 single vibrations, and not by the fork constructed by the Commission. Moreover the standard French forks made by Koenig were substantially correct in rate. The difference is, of course, too slight to be of any consequence in practice.

The International pitch has come to be generally adopted, so that it is now the standard pitch of this country, although it seems to be customary to tune pianos for use at concerts somewhat sharp, even up to A_3 440 vibrations, which is in fact the "Stuttgart pitch" of 1834.

At various times during the past twenty years the writer has taken the opportunity to ascertain the rates of such tuning-forks and other standards of pitch as were accessible. The results of a considerable number of these measurements were published in the "American Journal of Otology" for October, 1880, in a paper "On the Present Condition of Musical Pitch in Boston and Vicinity," by Charles R. Cross and William T. Miller. The later measurements have not hitherto been published. These have been made in part by the writer and in part by several of his assistants in the Rogers Laboratory, Messrs. Goodwin, Mansfield, Wendell, and Burgess. The present paper is intended to include such results as are likely to be of general interest.

Table I. is reprinted from the paper of Messrs. Cross and Miller. The tonometer forks available at the time of its publication were less accurate than those which have been procured subsequently, so that in certain cases, where the standards measured in 1880 were still accessible a remeasurement has recently been made, the results of which will be found in Table II. Where this has been done, it is indicated in the tables by an asterisk prefixed to the number designating the standard. By a comparison of Tables I. and II. it will be seen that the remeasurements have not materially altered the values obtained in the earlier measurements.

The standard C fork upon which the measurements of 1880 were based was a C_3 fork (No. 1 of Table I.) by Koenig, belonging to the Massachusetts Institute of Technology, the rate of which had been determined by comparison with a C_3 fork by Koenig belonging to the Stevens Institute of Technology, which last fork had been very carefully rated by Professor A. M. Mayer of that institution. The standard A used was a fork by Koenig assumed to be exact. From these the forks of an improvised tonometer were rated, the C forks being of pitch C_3 and

TABLE I.

No.	Designation.	Vibration Frequency.	Remarks.
		C_3	
*1	Koenig, physical pitch . . .	256.1	Stamped 512 *v. s.*
*2	Koenig, French pitch (approximate)	260.2	Stamped 520 *v. s.*
*3	Koenig, German pitch . . .	264.2	Stamped 528 *v. s.*
*4	Ritchie, physical pitch . . .	256.2	
5	Koenig, physical pitch . . .	256.2	Stamped 512 *v. s.*
6	Marloye, physical pitch . . .	256.4	Made between 1845–50.
7	Ritchie	259.1	Made about 1868.
8	Ritchie	259.4	" " "
*9	Ritchie, copy of Chickering's standard.	269.0	Made about 1868.
*10	Mason & Hamlin, French pitch	259.1	Used for a few years only.
11	Hutchings, Plaisted & Co . .	264.0	Low organ pitch, C_4 fork measured.
12	Hook & Hastings, old flat organ pitch	264.6	C_4 pipe measured. Temperature, 69° F.
13	Organ in church of the Immaculate Conception, Boston .	266.7	C_4 pipe measured. Temperature, 69° F.
14	Smith American Organ Co. .	267.2	C_4 fork measured.
15	New England Organ Co. . .	268.2	C_4 fork measured.
*16	Chickering's standard fork. .	268.5	C_3 fork, marked "1865, standard pitch."
*17	H. F. Miller, pianos	268.9	C_4 fork measured.
*18	Mason & Hamlin, present standard pitch	269.0	C_3 fork measured.
19	Fork of W. H. Clement, tuner.	269.2	C_4 fork measured.
20	George Woods & Co., cabinet organs	269.5	C_4 fork measured.
21	Hook & Hastings, present standard pitch	270.0	C_3 and C_4 pipes measured. Temperature, 73° F.
22	Chickering piano used at Joseffy concerts, 1880.	270.1	C_4 fork of tuner measured.
*23	Covent Garden pitch, 1879. .	270.3	C_4 fork furnished by R. Spice.
24	Weber pianos	270.3	String of piano measured.
25	Thomas' pitch	271.1	C_4 fork furnished to builders of great Cincinnati organ.
26	Music Hall organ	271.2	C_3, principal, great. Temperature 70° F.
*27	Steinway's pitch	272.2	C_4 fork furnished by R. Spice.
*28	Highest New York pitch . .	273.9	C_3 " " " "
		A_3	
29	Nichols' fork, Boston, Germania orchestra	448	Corresponding to untempered C_3, 269
*30	Marloye's A fork	426	Imported by Prof. Lovering, 1845–50.
*31	Florence pitch, Marloye. . .	438	" " "
*32	Vienna pitch, Marloye . . .	446	" " "
33	Milan pitch, Marloye	448	" " "

mostly large forks, while the A forks were the ordinary musicians' small A_3 tuning forks, tuned by the authors to convenient pitches. The same forks were used for several years subsequent to 1880.

In the recent measurements three large standards of Koenig have been used as a basis, viz.: a C_3 of 256 double vibrations, a tempered C_3 of 258.65 vibrations, and an A_3 of 435 vibrations, at a standard temperature of 20° C. From these were rated by the method of beats, a series of large C_3 forks and also two sets of C_4 small Scheibler's tonometer forks by Koenig, and two sets of A_3 forks of the same character. These small tonometer forks were also compared with a series of large Scheibler tonometer forks by Koenig, which last were assumed to be correct within the limits sought in our measurements.

Table II. gives the results of ratings of various standards of epochs indicated by the date. In all measurements later than 1891 the Koenig standard tonometer forks have been employed. The data given in Table II. are all in terms of the pitches of C_4 and A_3. The pitch of the standards actually measured is specifically stated in all cases except when it is C_4 or A_3.

Table III. contains the results of measurements of fifty-six forks sent by various manufacturers to the Committee of the National Piano and Organ Manufacturers' Association in response to their request already referred to. A preliminary rating was made by me in 1890–91 with such forks as I then possessed. The results of this were shown in a circular privately printed in 1891 for the use of members of the Association. A more exact determination was made by me a few months later in 1891, using the Koenig tonometer forks as previously stated. The results of these measurements are found in the table.

Certain of the forks and other standards referred to in Table II. deserve special mention. Those numbered 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 87, 88 were intended to give the physical pitch. Nos 2 and 3 had been in the possession of their owners for many years, and were authenticated as to the date assigned to them. Nos. 5 and 6 are two forks belonging to Harvard University, imported many years since. No. 5 is of the early Marloye pattern, with inclined prongs, but does not bear any mark to indicate the maker. No. 6 bears the mark "R. K.," always employed by Koenig. Nos. 16 and 17 are also Koenig forks of early date, belonging to Harvard University. No. 8 is a pitch pipe formerly employed for church use, belonging to Mr. B. J. Lang of Boston. It is a whistle with a movable plug, and the pitch can be varied through an octave. When the plug is set for C_4, according to the lines

TABLE II.

C_4

No.	Vibration Frequency.	Designations and Remarks.
1	506	Tonic Sol-Fa, 1882. N. E. Conservatory of Music. Rated in 1882.
2	509.7	Old Fork of J. T. Batchelder, 1782. Rated in 1884.
3	510.8	Old Fork of G. A. Emery, 1840. Rated in 1881.
4	511.1	E. S. Ritchie & Sons, Standard C_4; early fork.
5	511.5	C_3, 255.75, Marloye pattern, Harvard University.
6	511.7	C_3, 255.85, R. K.,; early fork, Harvard University.
7	511.8	C_3, 255.9, Tufts College.
8	512	Early Pitch Pipe, Maker's Standard. T = 23° C. B. J. Lang.
9	512.1	C_3, 256.05, R. K. "512 *v. s.*," slender pronged; early fork, M. I. T.
*10	512.1	C_3, 256.06, R. K. "512 *v. s.*," 1873, Basis of measurements of 1877, M. I. T.
11	512.2	C_3, 256.1, E. Greaves, "Scheibler Pitch."
12	512.2	R. K. "1024 *v. s.*," M. I. T.
*13	512.3	E. S. Ritchie & Sons, Standard C_3, 256.17.
14	512.4	E. Greaves, "Scheibler Pitch, 512."
15	512.5	W. T. Miller, 1880. Physical Pitch.
16	512.6	C_3, 256.28, R. K., "512 *v. s.*,"; early fork (prior to 1868), Harvard University.
17	512.7	R. K., C_4 "1024 *v. s.*"; early fork, Harvard University.
18	514.7	Walmsley, Fuller & Co., Chicago, 1895.
19	514.8	C_2, 128.7, E. S. Ritchie & Sons, makers, University of Virginia.
20	515.5	L. K. Fuller; electrically welded fork, 1893.
21	515.6	Tempered C_4, French Pitch, 1883. Small Fork, M. I. T.
22	515.6	"517.3 Piano Mfrs. Ass'n." New England Conservatory, 1898.
23	517.0	"Philharmonic." Tufts College.
24	517.3	Pitch Pipe, 1826, Yale University.
25	517.3	Tempered C_4, French Pitch, 1884. Small Fork. Rated in 1884.
26	517.4	Miller's Standard Tempered C_3, 258.68, 1884. Rated in 1884.
27	517.5	Tempered C_4, Small Fork, French Pitch, 1883, Boston Symphony Concerts. M. I. T.
28	517.5	C_3, 258.78, Ritchie, early fork, Marloye pattern. M. I. T.
29	517.5	Tempered C_4, French Pitch, 1884. Large fork on box. M. I. T.
30	517.6	E. S. Ritchie & Sons, C_3, 258.78, early fork, Marloye pattern. M. I. T.
31	517.7	E. S. Ritchie & Sons, C_3, 258.83; early fork. University of Virginia.
32	517.8	Chickering & Co., new tempered C_3, 258.9, French Pitch, 1884. Rated in 1884.
33	517.8	Tempered C_4, French Pitch, 1883. M. I. T.
34	518	Early Pitch Pipe. Local Pitch, T = 23° C. B. J. Lang.
*35	518.5	Mason & Hamlin, Weighted C_3, 259.24. French "Standard 1866," Pitch.
36	518.7	G. S. Hutchings, "517.3," "International Pitch."
37	519.0	C_4 Pipe giving Thomas' Pitch of 1883. T = 22° C. Hook & Hastings.

TABLE II. — *Continued.*

No.	Vibration Frequency.	Designations and Remarks.
38	519.0	C_3, 259.5. N. E. Conservatory Standard of 1882; on box. Remeasurement, 1898.
39	519.2	Do. dismounted, 259.6. Do.
40	519.6	Do. on box, 259.8. Do.
*41	520.1	C_3, 260.07. R. K. "520 *v. s.*" 1873.
42	520.4	Pitch used by Patti, 1882. L. K. Fuller.
43	520.6	G. S. Hutchings. International Pitch, C_4, natural.
44	520.6	"522, Estey Organ Co." N. E. Conservatory.
45	520.6	"N. E. Conservatory, 1892." L. K. Fuller.
46	520.8	"522, Estey Organ Co." G. S. Hutchings.
47	520.9	"International Pitch." Fork of M. Steinert & Sons Co., Boston, 1898.
48	521.4	C_3, 260.7. French Pitch, on box, N. E. Conservatory Standard of 1882. Rated, 1883.
49	521.8	C_3, 260.9. Copy of N. E. Conservatory Standard of 1882, M. I. T., on box. Rating of 1883.
50	521.8	C_3, 260.9. E. S. Ritchie & Sons, Standard C, "261."
51	522.1	True French C_4, 1883. M. I. T.
52	522.2	C_3, 261.1. Copy of N. E. Conservatory Standard of 1882. M. I. T., off box. Rating of 1883.
53	522.4	C_3, 261.1. Copy of N. E. Conservatory Standard of 1882. M. I. T., on box. Rating of 1898.
54	523.5	Theodore Thomas' Pitch, 1882, N. E. Conservatory. Rated in 1882.
55	527	Whitney & Raymond Organ Co., 1882. N. E. Conservatory. Rated in 1882.
*56	528.2	C_3, 264.11, R. K., 1873, "528 *v. s.*," German Pitch. M. I. T.
57	532.8	C_3, 266.4. Princeton University.
58	535.3	R. & M., Richmond, Va. L. K. Fuller, 1883.
59	536.0	Standard Pipe, Pitch of 1884, "540." Hook & Hastings.
60	536.3	Hazelton, L. K. Fuller, 1883.
61	536.8	Fork of period 1880. W. T. Miller.
62	536.8	Decker, L. K. Fuller, 1883.
63	536.8	C_3, 268.4. Copy of Chickering's Standard "1865." N. E. Conservatory. Rated in 1882.
*64	536.9	C_3, 268.44, Chickering Co., Standard fork, "1865." "Concert Pitch."
65	537.3	McPhail, L. K. Fuller, 1892.
*66	537.5	Miller, standard of 1880.
*67	537.9	C_3, 268.96. E. S. Ritchie & Sons, 1870. Copy of Chickering's Standard.
68	538.1	Hodge & Essex, L. K. Fuller, 1892.
*69	538.2	C_3, 269.1. Mason & Hamlin Co., "Standard Pitch, 1866."
70	538.3	Isotonic Fork, High Pitch, 1880.
71	538.6	"C, 540," Estey Organ Co. N. E. Conservatory.
72	538.9	"540," Estey & Co. G. S. Hutchings.
73	539	Chickering Concert Pitch, 1882. N. E. Conservatory. Rated in 1882.
74	539.3	"Philharmonic." L. K. Fuller, 1883.
75	539.8	E. Greaves, "540, Scheibler Pitch."
*76	540.2	"Covent Garden," 1879. R. Spice.
77	541.4	W. T. Miller, Fork of period, 1880.
78	542.5	Sanders, L. K. Fuller, 1883.
*79	544.5	Steinway, New York, 1880. M. I. T.

TABLE II. — *Continued.*

No.	Vibration Frequency.	Designations and Remarks.
80	545	Theodore Thomas' High Pitch prior to 1893. N. E. Conservatory. Rated in 1883.
81	545.1	Reed Pitch Pipe, 1885. Rated in 1885.
*82	547.7	C_3, 273.85, Highest New York Pitch, 1878. R. Spice.
83	549.0	"Philharmonic Pitch," Standard Fork of Steinert & Sons Co., 1898.
		A_3
84	415.3	A_2, 207.7 "Shore Fork," 1715. L. K. Fuller.
85	422.3	"Händel Fork," 1749. L. K. Fuller.
86	423.7	Pipe, Pitch of 1889, Hook & Hastings, T = 21.7° C.
87	426.2	A_2, 213.1, Ritchie, early fork, University of Virginia.
*88	426.5	Marloye, "853⅓." Harvard University.
89	428.8	Tufts College.
90	432.8	French A, Boston Symphony Orchestra, Henschel's original small fork, 1883.
91	433.0	Ritz, L. K. Fuller, 1883.
92	434.3	"Piano Mfrs. Ass'n." G. S. Hutchings.
93	434.5	"A, 435, Piano Mfrs. Ass'n." N. E. Conservatory.
94	434.6	"A, 435, Piano Mfrs. Ass'n." M. I. T., from L. K. Fuller.
95	434.7	E. Greaves "French Pitch."
96	434.8	R. K., French Pitch, correct at 15° C. 1883, M. I. T.
97	434.9	Electrically welded fork, L. K. Fuller, 1893.
98	434.9	R. K., A 435 at 20° C. Mason & Hamlin Standard, 1898.
99	435.0	Standard R. K., "870 *v. s.* at 20°." G. S. Hutchings.
100	435.0	R. K., A 435 at 20° C. H. F. Miller, Standard, 1891.
101	435.0	R. K., A 435 at 20° C. Chickering Co., Standard, 1898.
102	435	Pitch Pipe, 1826. Yale University.
103	435.4	Ritz. L. K. Fuller, 1883.
104	435.4	Small R. K. Fork, "870 *v. s.*," Tufts College.
105	437.4	Theodore Thomas' Pitch, 1883. M. I. T.
106	437.7	Theodore Thomas' Pitch, 1883. Georg Henschel. Rated in 1883.
107	437.8	Ritz. L. K. Fuller, 1883.
108	438.1	"French Pitch." L. Waldo, 1898.
*109	438.4	"Florence Pitch." Harvard University.
110	441.3	E. Greaves, "Scheibler Pitch," German Pitch.
*111	446.0	"Vienna Pitch." Harvard University.
112	446	Reed Pitch Pipe. Rated in 1885.
113	446.7	Carl Eichler, L. K. Fuller, 1883.
114	448.0	L. K. Fuller, 1883.
115	448.5	Boston Symphony Orchestra, Standard A, 1882–83.
116	449.1	L. K. Fuller, 1883.
117	451.5	Chickering's Pitch, L. K. Fuller, 1883.
118	454.1	W. T. Miller, 1880.
119	457.5	L. K. Fuller, 1883.
120	457.7	Steinway, L. K. Fuller, 1883.

made for the purpose, the rate is, as given in the table, 512 vibrations. Notches have been cut in certain places, apparently to give the "local pitch" used by the choir. When adjusted by these (see No. 34), the rate is 518, practically French pitch. The frequency of vibration of such a pipe is of course greatly influenced by the temperature. This pitch pipe was used in a church in West Townsend, Mass., early in the present century, and its pitch was adjusted to that in use in Boston.

No. 10 is a Koenig fork already referred to, made for the Massachusetts Institute of Technology in 1873, and used as the basis of measurements by Cross and Miller in 1880. Like all of Koenig's forks, prior to the establishment of his new standard in 1880, it is a little sharp. Nos. 11, 14, 95, 110 are forks made by Mr. E. Greaves. No. 13, the standard C_3 of E. S. Ritchie and Sons, was procured from Duboscq of Paris at a date prior to 1870. It has the inclined prongs of the Marloye forks. Nos. 19, 31, 87, are large forks made for the University of Virginia by E. S. Ritchie and Sons more than twenty-five years since. No. 24 is a pitch pipe deposited in the library of Yale University by the class of 1826, and kindly rated by Professor A. W. Wright. No. 102 is the same pipe when set to give A_3. When properly blown it gives, substantially, French pitch. No. 26 is a fork used by Miller and Sons as their standard for piano pitch in 1884. No. 29 is one of a pair of large forks on resonating boxes made in 1883, for the purpose of tuning the Chickering piano when used in the Boston Symphony Concerts, the orchestra having adopted the French pitch. It was tuned from No. 27. The firm desired to tune the piano from C rather than from A. No. 32 is a large tempered C fork, adopted in 1884 by the Chickerings for tuning pianos to be used with orchestras employing the French pitch. No. 35 is the standard French Pitch of the Mason and Hamlin Co. The fork No. 69 is lowered in pitch by attaching to each prong by wax a small rectangular piece of steel. No. 36 is a fork of G. S. Hutchings and Co., used in tuning the organs made by them. No. 37 is a flue pipe belonging to the Hook and Hastings Organ Co., and giving the pitch proposed by Theodore Thomas in 1883. Nos. 38, 39, 40 give ratings under different conditions of a large standard fork made by Ritchie and Sons for the New England Conservatory of Music in 1882. No. 48 is the same as measured in 1883. The fork has flattened by a considerable amount since its manufacture, from unknown causes. It has apparently been kept with care. The box has a considerable influence upon the pitch of the fork. No. 42 is a fork belonging to Mr. Levi K. Fuller, giving the pitch which was used in opera in 1882 by Patti. It is a little sharp of French pitch, though

far below the high pitch then habitually used in this country. No. 47 is a small fork, the standard for "International Pitch" of the M. Steinert and Sons Co., Boston. Nos. 1, 54, 55, 63, 71, 73, are forks belonging to Mr. F. W. Hale of the New England Conservatory of Music. No. 57 is an old C_3 fork belonging to Princeton University, and probably dating from the time of Prof. Joseph Henry. It is considerably rusted. No. 59 is a flue pipe giving the high pitch used by Hook and Hastings in 1884. No. 64 is the former standard fork of the Chickerings, made in 1865, and giving the high concert pitch then in vogue. It is a large C_3 fork, marked "1865, Standard Pitch," with its prongs inclined towards one another. No. 67 is a copy of the Chickering fork made by E. S. Ritchie and Sons for their own use in 1870. It has sharpened somewhat after tuning. No. 69, the Mason and Hamlin Co.'s former standard, is a large fork, almost a counterpart of the Chickering fork. It is marked "Standard Pitch, 1866." No. 76 is a small fork furnished by Mr. Robert Spice of Brooklyn, in 1879, and giving the pitch then used in the Covent Garden Theatre. No. 82 is a bell metal fork made in 1878 by Mr. Spice, and giving the highest pitch then used in New York. No. 83 is a small fork at the high "Philharmonic Pitch" of the Steinert and Sons Co.

Among the A_3 forks, No. 84 is a very old and low-pitched fork, procured by Mr. Levi K. Fuller in England, and purporting to have been made in 1715 by John Shore, the inventor of the tuning-fork, and to be the oldest fork in existence. No. 85, which also belonged to Mr. Fuller, is supposed at one time to have been used by Händel. No. 86 is a pipe giving the pitch settled upon by Hook and Hastings in 1889. Nos. 88, 109, 111 are small forks imported by Prof. Joseph Lovering for Harvard University, between 1845 and 1850. No. 90 is one of a number of small forks made for Mr. Georg Henschel in 1883 as a basis for the pitch of instruments to be made for the Boston Symphony Orchestra. It was tuned from the forks of a Valentine and Carr tonometer (see No. 3, Table V.), and owing to the extreme flatness of the "A,432" and "A,436" used in the comparison, it is considerably below French pitch. No. 96 is a standard A_3 "French Pitch," by Koenig, imported by the Massachusetts Institute of Technology in 1883. It is correct at 15° C., and hence at 20° C., the present standard temperature, is slightly flat. Nos. 98, 99, 100, 101 are large Koenig standard forks, mounted on boxes. No. 102 is the same pitch pipe as No. 24 when adjusted to give the Note A_3. Nos. 105, 106 are small forks giving the medium pitch proposed and used by Theodore Thomas in 1883. No. 106 was given to Mr. Henschel

by Mr. Thomas. No. 105 was copied from this. No. 113 is a fork giving the pitch used by the Germania Orchestra in 1883. No. 115 is a high A_3 fork, made by Mr. R. Spice, and belonging to the Massachusetts Institute of Technology, which was used by the Boston Symphony

TABLE III.

C_4 Forks.

No.	Designation.	Vibration Frequency.
1	Knabe & Co., Baltimore (Low Pitch)	508.8
2	Roosevelt Organ Co., N. Y.	516.8
3	C. B. Snyder, Winfield, Kan.	518.8
4	J. H. &. C. S. Odell, N. Y.	520.6
5	Chickering & Sons, Boston (Low Pitch)	521.3
6	J. & C. Fischer, N. Y.	526.4
7	Wilcox & White Organ Co., W. Meriden, Conn	531.6
8	Jewett & Co., Leominster, Mass.	532.3
9	Shoninger Organ & Piano Co.. New Haven, Conn.	533.9
10	Gallup & Metzger, Hartford, Conn.	534.0
11	J. H. Foote, N. Y.	534.9
12	Francis Bacon, N. Y.	535.8
13	Dyer & Hughes, Foxcroft, Me.	536.1
14	A. Weber, N. Y.	536.9
15	Mason & Hamlin Organ & Piano Co., Boston	537.1
16	Vose & Sons, Boston	537.1
17	Benning & Sons, N. Y.	537.4
18	C. C. Briggs & Co., Boston	537.5
19[1]	A. M. McPhail Piano Co., N. Y.	537.8
20	Chickering & Sons, Boston (High Pitch)	538.2
21	Clough & Warren Co., Detroit	538.4
22	Atlanta Piano Co., Atlanta, Ga.	538.9
23	Geo. Steck & Co., New York	539.0
24	Wm. E. Wheelock & Co., N. Y.	539.1
25[1]	Boardman & Gray, Albany, N. Y.	539.2
26	Estey Piano Co., N. Y.	539.7
27	Decker Bros., N. Y.	539.8
28	Mehlin & Sons, N. Y.	539.8
29	R. M. Bent & Co., N. Y.	539.9
30	Pease Piano Co., N. Y.	540.0
31	A. B. Chase Co., Norwalk, Ohio	540.4
32	Newby & Evans, N. Y.	540.6
33	Knabe & Co., Baltimore (High Pitch)	540.9
34	Stirling Co., Derby, Conn.	541.8
35	Hazelton Bros., N. Y.	542.1
36	Decker & Son, N. Y.	542.1
37	Conover Bros., N. Y.	542.5
38	Sherman Clay & Co., San Francisco	545.2
39	Lester Piano Co., Philadelphia	547.1
40	Leicester Piano Co., Leominster, Mass.	549.8

[1] Forks very poor and hard to rate.

TABLE III. — *Continued.*

A_3 Forks.

No.	Designation.	Vibration Frequency.
41	P. Werlein, New Orleans, La	431.8
42	Mason & Hamlin Organ & Piano Co., Boston	434.6
43	" " " " Philadelphia	439.3
44[1]	C. H. W. Ruhe, Pittsburg, Pa.	441.9
45[1]	Hook & Hastings, Boston	443.5
46	Clough & Warren Organ Co., Detroit	444.6
47	Kranich & Bach, N. Y.	444.6
48[1]	Geo. Jardine & Son, N. Y.	447.1
49	J. H. Foote, N. Y.	449.8
50	W. W. Kimball Co., Chicago	451.4
51	Hallet, Davis, & Co., Boston	453.2
52	Sohmer & Co., N. Y.	454.5
53	Krakauer & Bros., N. Y.	454.8
54	Steinway & Sons, N. Y.	456.0
55	Chas. M. Stieff, Baltimore	456.2
56	Keller Bros. & Blight, Bridgeport, Conn.	458.2

TABLE IV.

Forks issued in 1892 as representing "International Pitch."

A_3			C_4
M 424.1	M 434.4	M 445.0	M 516.3
M 429.8	M 434.6	M 445.5	M 517.2
N 432.3	M 434.8	M 491.9	M 517.7
M 433.1	M 435.4	M 498.1	M 519.4
N 433.3	O 435.7		M 520.2

Orchestra as a standard in 1882–83, the year prior to the introduction of the French pitch. In the following years an exact copy of No. 96, a large Koenig A_3 435 fork mounted on a resonating box was used, which was subsequently replaced by an electrically driven fork made by Wolters of Vienna. The orchestra also possesses a Koenig A_3 fork

[1] Forks very poor and hard to rate.

mounted on a box and giving International (French) pitch, with which the last-mentioned fork can be compared.

In Table IV. are given the rates of a number of small musicians' forks loaned by Mr. L. K. Fuller, which were sold in 1892 as representing the new "International Pitch." The attached letters, M, N, O, denote the different dealers who furnished them. It will be seen that the C_4 forks range from, approximately, 516 to 520 vibrations, the true value being 517.3 vibrations, and the A_3 forks from 424 to 498 vibrations, the difference in the latter case amounting to over a major tone, and showing an extreme of carelessness in tuning and comparison that is almost incredible.

TABLE V.

Tonometer Forks. Valentine and Carr.

Designated Frequency.	Measured Frequency.				
	1	2	3	4	5
420	419.6	417.5			
424	423.6	421.5			
428	427.7	425.5			
432	431.8	429.5	429.8	430.3	
436	435.7	433.4	433.7	434.4	
440	439.8	437.5	437.4	438.3	
444	443.4	441.2	441.2	442.5	
448	447.3	445.6	445.5	446.6	
452	451.1	449.3			
456	454.9	453.3			
256			255.8	255.8	
512			511.2	511.8	512.0
516			515.4		
536			535.3		
540			539.2		539.0

Ratings have also been made of forks selected at random from several tonometers. In Table V. will be found the results of measurements upon forks from four tonometers by Valentine and Carr. The forks are all of the small pattern ordinarily used by that firm. The numerals 1, 2, 3, 4, 5, heading the corresponding columns indicate the particular set of

forks referred to. With the exception of No. 5, the tonometers are long range ones, running from C_3 to C_4. No. 5 is a short range tonometer of 12 forks, from 512 to 544 vibrations, purchased by the Massachusetts Institute of Technology, in 1882. No. 1 belonged to Mr. Levi K. Fuller and was purchased by him in 1892. No. 2 was made for the Massachusetts Institute of Technology in 1882. No. 3 refers to the same tonometer. The values under (2) were obtained by comparison of the forks with those of (1). The values under (3) were obtained by direct comparison with Koenig's forks, as were all the results in Table V. except those under (2). No. 4 is a tonometer belonging to Harvard University, and which was purchased by Professor Lovering about 1883. The forks taken for comparison were A_3 and C_4 forks. It will be seen that the error is in some cases very considerable, amounting for some of the A_3 forks to several vibrations.

The small tonometer forks of Koenig are usually closely in accord with his large standard and tonometer forks, not often deviating from the numbers stamped upon them by as much as one tenth of a double vibration.

In all the measurements referred to in the present paper time-intervals were measured by the use of an accurate stop-watch reading to one-fifth of a second.

ROGERS LABORATORY OF PHYSICS,
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